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# The HELP hospital information system: update 1998

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**Abstract**

The HELP hospital information system has been operational at LDS Hospital since 1967. The system initially supported a heart catheterization laboratory and a post open heart Intensive Care Unit. Since the initial installation the system has been expanded to become an integrated hospital information system providing services with sophisticated clinical decision-support capabilities to a wide variety of clinical areas such as laboratory, nurse charting, radiology, pharmacy, etc. The HELP system is currently operational in multiple hospitals of LDS Hospital's parent health care enterprise—Intermountain Health Care (IHC). The HELP system has also been integrated into the daily operations of several other hospitals in addition to those at IHC. Evaluations of the system have shown: (1) it to be widely accepted by clinical staff; (2) computerized clinical decision-support is feasible; (3) the system provides improvements in patient care; and (4) the system has aided in providing more cost-effective patient care. Plans for making the transition from the 'function rich' HELP system to more modern hardware and software platforms are also discussed. © 1999 Elsevier Science Ireland Ltd. All rights reserved.

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## 1. Historical introduction to HELP system

HELP was the first hospital information system to collect patient data needed for clinical decision-making and at the same time incorporate a medical knowledge base and inference engine to assist the clinician in making decisions [1]. The original system was developed at the LDS Hospital in Salt Lake City (UT, USA), by a team led by the three authors, fellow faculty members, graduate students, programmers, engineers, and prac-

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ticing clinicians. LDS Hospital is a 520 bed private acute care hospital affiliated with a parent organization known as Intermountain Health Care (IHC). Although the authors and their colleagues carried out the development of the HELP system at LDS Hospital, many of the contributors were faculty members and students of the Department of Biophysics and Bioengineering (now called Medical Informatics) at the University of Utah.

The early days of research into the applications of computers to medicine at the LDS Hospital were directed toward the processing of analog signals using analog computers. At the time, we were interested in techniques for diagnosis and evaluation of patients with cardiovascular abnormalities and in the understanding of how the circulation was controlled. With the analog computer we could build and explore a variety of mathematical models, comparing the model with the real system. For example, the pressure wave generated by the ejection of blood into the aorta with each systole is distorted as it propagates down the aortas, and this distortion can be reproduced by an electrical analog in the form of a second order differential equation. When the electrical signal from a transducer recording the upstream pressure waveform is fed into such a circuit the parameters (resistance, inductance, and capacitance) may be adjusted so that the output from the circuit matches very closely the waveform recorded from a transducer downstream in the circulation [2]. With the analog computer we built models of sympathetic and vagal control of heart rate of the carotid sinus and of the regulation of cardiac output during exercise. It was, however, not these efforts but our success with the use of the digital computer in the diagnosis of congenital heart disease that resulted in our receiving a grant to establish a computing research facility with support through the Intermountain Regional Medical Program from the Public Health Service in 1967.

Because one of the authors (HRW) had responsibility for the cardiovascular laboratory at the hospital, our first applications of the digital computer focused in that area. We developed programs for recognizing waveforms generated by the transducers used for assessing cardiovascular function such as the electrocardiogram, pressure signals from various locations in the circulation, hemoglobin saturation with oxygen, and cardiac output from measurements of the time course of indicator concentration. After automating much of the data collection, analysis. and reporting functions for the heart catheterisation laboratory, we moved most of these functions into other environments such as the operating rooms and the intensive care units (ICU).

In the post-open-heart surgery ICU we (author RMG) developed a sophisticated work station for the ten beds being monitored. At the nurses' station above the computer display was a bank of lights: a red, yellow and green light for each bed. The green light was turned on whenever a pressure waveform from a pressure transducer for that patient was being sampled by the computer. The yellow light indicated an abnormal trend in some variable either measured or calculated, and the red light indicated an emergency situation detected by the computer. The nurse could press a yellow light and the computer would plot a graph of the time course of the abnormal variable. One day, as one of the authors (HRW) visited this unit, he saw a yellow light was turned on for one of the patients. A nurse was at that patient's bedside taking the blood pressure with a cuff on one arm, even though the patient had an arterial catheter for recording pressure in the other arm. When the nurse returned to the nursing station she seemed a little embarrassed about what she had been doing and offered no explanation. It was clear, however, that the computer had not provided her with information she could interpret; there appeared to be an information overload. On reviewing the patient's data with the resident surgeon, and then calling the attending surgeon who had performed the open-heart surgery on the patient 2 days before, it was determined that the patient was developing a cardiac tamponade. The patient was promptly taken back to the operating room to stop the bleeding. Wouldn't it be nice, we thought, if we could build a model of the decision-making process we had just been through, so that the computer could recognize such a pattern of events if it should occur again with some other patient? This was the idea that led to the development of the data-driven clinical decision-making system that became known as HELP.

The first version of HELP was written in assembly language for the Control Data Corporation (CDC) 3200 computer. The knowledge base consisted of a set of frames, each designed to occupy one 'sector' of disc space for purposes of efficiency. The frames were referred to as 'HELP sectors' in those days. Each frame had a message with text that could be modified depending on the outcome after processing the frame's logic. Items of data to be used by the decision were elements from the patient's computer-based medical record and each item had modifiers which directed the search of that record. For example, last value of serum potassium since 24 h before item A (prescription for digitalis).

In the original publication of HELP [3], the goals for the system were described. Each decision frame must represent the best current medical knowledge and be easily modified as new knowledge appeared, without requiring a change in any program. The logic must be expressed in a text form that could be understood by the clinical expert and the system must provide an explanation of any decision suggested to the nurse or clinician receiving it. Once a decision was made, it could be treated as a data item for another frame, allowing a hierarchical decision structure. A structured vocabulary was used to avoid ambiguity in data representation wherever possible [4].

The actual implementation of the HELP system concepts were made possible by using individual bits in the computers 24 bit words of the CDC computer to represent both data structures and knowledge. Each user was allocated 2048 words of memory for programs and data and could make use of overlays running in an interrupt-driven timesharing system developed by one of the authors (TAP). All programming was done in assembly language by faculty members, students, and a few full-time programmers. Although the programming was tedious and inconvenient, the run-time system was very efficient. For 16 years this system sampled and analyzed analog signals from ICU's, operating rooms, laboratories, and screening clinics, performed admit, discharge, and transfer functions for patients, generated reports, made thousands of decisions every day and served many clinical data processing tasks for the hospital. During this time, several tasks were gradually taken over by smaller front-end processors.

In the late 1970s the demand to have a system operational 24 h per day and 7 days per week required more reliable computers. Thus, in 1982 the HELP system was converted from dual CDC computers with manual 'backup' to a TANDEM computer configuration, to maximize the system availability offered using the newly developed redundant computer hardware and software. The HELP system continues to run newer

TANDEM computers at the moment, with a system availability of better than 99.85% (about 2 min per day downtime) for the year 1997. Initially 'home built' computer terminals were used and RS-232 serial links were used. However, today the hospitals with HELP installed use Pentium PCs as terminals with ATM and Ethernet local area networks for communications. Since the HELP system has many clinical applications that require nurse, therapist, pharmacist, and physician to provide timely bedside data entry, virtually every hospital bedside is equipped with a computer terminal.

## 2. Current HELP system

Fig. 1 shows an outline diagram of the HELP systems as they are currently installed at nine IHC hospital facilities. Each hospital has its own integrated clinical database and uses a common coding system for storing encoded data [5–7]. Laboratory ordering data are sent to the Sunquest clinical laboratory system via an HL-7 interface. Likewise, results from the clinical laboratory are forwarded to the HELP system using an HL-7 interface such that all laboratory results, including microbiology results, are stored in coded form and promptly available in the HELP system's integrated clinical database. Other computer interfaces are available from the ICUs and surgery, where direct interfaces with bedside monitoring equipment and the medical information bus (MIB) automatically gather data from monitoring devices, IV pumps and other bedside equipment [8–10]. Once each day, data from the HELP system is 'downloaded' to the AS400 accounting system. These data include billing for medications given, procedures performed, etc. In

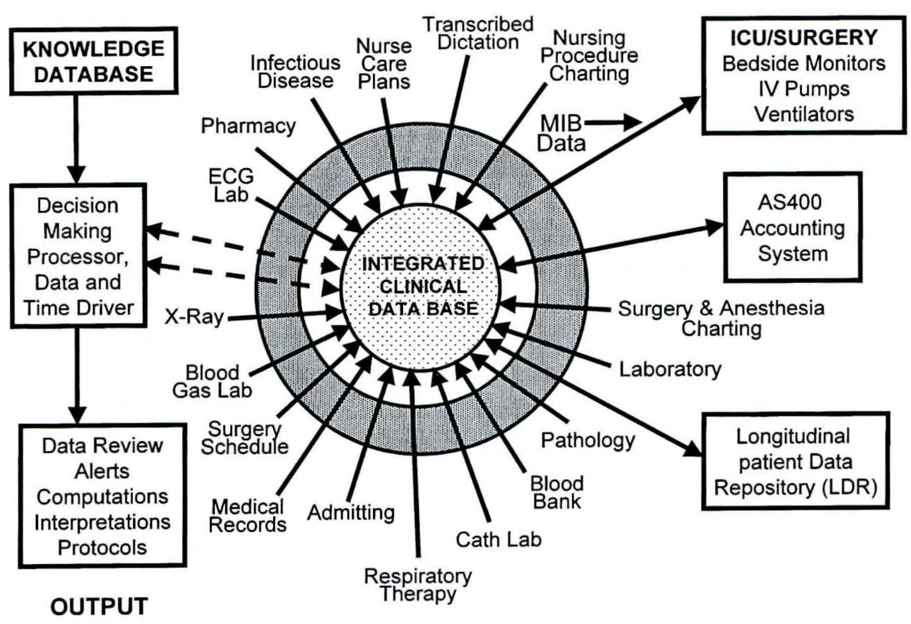


Fig. 1. Block Diagram of the HELP System with its integrated centralized database, interface to the IBM AS400 billing system and newly implemented longitudinal patient data repository (LDR). As data flows into HELP's integrated database either by a 'data drive' mechanism or a 'time drive' mechanism the knowledge base and decision support capabilities of the HELP system are activated.

addition, data from the HELP system is archived into a longitudinal patient data repository (LDR). Data in the 'local' repository server at LDS Hospital are available for the last 12 years. In recent years 'free text' data from current transcriptions of history and physical and other transcribed reports (radiology etc.) are stored on the HELP system, as are archival copies of transcription from previous patient visits.

A key differentiator of the HELP system from many integrated health information systems continues to be its capability of making 'medical decisions.' For example, as data are stored in the HELP integrated database, the system can 'data drive' and use the knowledge base to make decisions from the data as it is stored. For example, a serum potassium of 6.2 meq/l will trigger an elevated potassium alert to the nurse caring for that patient via a digital pager [11]. Time driven decision making capabilities are also available with the HELP system. Using data from transcribed reports natural language processing has recently become a major source of data for decision making [12–14] (Table 1).

Table 1 outlines the nine IHC locations where the HELP system is installed. The date of the installation, number of beds at each location and a broad overview of functional applications are provided. With these nine hospital installations 82% of IHC's inpatients and 86% of IHC's day patients are covered by the clinical HELP system. Note that there are over 2000 beds covered in these nine hospitals, with over 4700 terminals and 1100 laser printers. The earlier installations have more HELP system application features installed than the more recent installations. During the 1999 calendar year, all the remaining small rural hospitals that are part of IHC will have the HELP system installed to resolve the 'year 2000' problem resulting from older computer systems installed at those locations (total hospitals = 22).

In addition to the nine HELP sites within IHC there are five other health care facilities that have the HELP systems installed. These systems were installed by 3M Health Information Systems group. The health care facilities are:
1. Rex Healthcare, Raleigh, NC, 394 beds;
2. Arnot Ogden Medical Center, Elmira, NY, 271 beds;
3. Miami Valley Hospital Dayton, OH, 811 beds;
4. Deaconess Billings Clinic Health Systems, Billing MT, 280 beds; and
5. Mercy Hospitals Scripps Health San Diego, CA, 540 beds.

As a result, the HELP system is currently installed in hospitals with over 3900 beds.

## 3. Evaluations of the HELP system

The HELP system has been evaluated in several ways. Three examples which illustrate the applicability of the system in three different contexts will be discussed.

### 3.1. Questionnaire evaluation of user acceptance

In the early 1990s physicians and nurses were queried about several factors about the HELP system [15]. Fixed-choice questionnaires with Likert-type scales were returned by 246 physicians and 374 nurses. Age, specialty, and general computer experience did not correlate with attitudes about the computer system. Ready access to patient data such as laboratory findings and clinical alerts were rated highly. Respondents did not feel that HELP's expert system capability would lead to external monitoring or sanctioning. Also, both physicians and nurses did not feel that computerized decision support decreased their decision-making powers [15]. Free text

Table 1
Locations sites of HELP system within intermountain health care and operational status

| Hospitals | LDS Hospital | McKay-Dee Hospital | Primary Children's Hospital | Cottonwood Hospital & TOSH | Utah Valley Hospital | American Fork Hospital | Alta View Hospital | Orem Hospital | Dixie Hospital | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Data & function | | | | | | | | | | |
| HELP installed | Jan-72 | Nov-89 | Nov-91 | Nov-92 | Aug-93 | Dec-93 | Apr-95 | Feb-98 | Apr-98 | 9 hospitals |
| # Beds | 520 | 380 | 232 | 227 | 395 | 72 | 70 | 20 | 106 | 2022 beds |
| Admissions (1997) | 20 333 | 12 719 | 9505 | 10 538 | 17 964 | 4622 | 4723 | 1489 | 8479 | 90 372 patients |
| Terminals | 1418 | 749 | 742 | 423 | 742 | 245 | 140 | 131 | 111 | 4701 terminals |
| Printers | 321 | 151 | 184 | 161 | 117 | 66 | 53 | 20 | 39 | 1112 printers |
| Admit/discharge/transfer | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 9 |
| Medical records | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | 8 |
| Results review (lab etc.) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | 7 |
| Order entry | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | 7 |
| Pharmacy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | 7 |
| Radiology | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | No | 7 |
| Nursing documentation | Yes | Yes | Partial | Yes | Yes | Yes | No | No | No | 6 |
| Microbiology | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | 6 |
| Alerts | Yes | Yes | Yes | Yes | Yes | Yes | No | No | No | 6 |
| Flow sheets | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | 6 |
| Intensive care unit | Yes | Yes | Yes | Yes | Yes | No | No | No | No | 5 |
| Nursing protocols | Yes | Yes | No | Yes | Yes | Yes | No | No | No | 5 |
| Respiratory care | Yes | Yes | Yes | Yes | Yes | No | No | No | No | 5 |
| Surgery scheduling | Yes | No | No | Yes | Yes | No | Yes | No | No | 4 |
| Infectious disease | Yes | No | No | Yes | Yes | No | No | No | No | 3 |
| Functions | 15+ | 13 | 10+ | 14 | 14 | 11 | 8 | 4 | 2 | |

comments from the questionnaires provided encouragement for future development and deployment of medical expert systems at LDS Hospital and sister IHC hospitals. At the time of these questionnaire inquiries, there had been some concern that medical expert systems would not be adopted nor appreciated by clinicians. The questionnaire findings showed great support for such capabilities.

### 3.2. Infectious diseases

The infectious diseases features of the HELP system have grown from some initial prophylactic antibiotic reminder capabilities in 1985 to the very sophisticated 'antibiotic assistant' reported in 1998 [14,16–27]. A 1989 study reported that reminders given to physicians increased compliance for prophylactic antibiotic use from 40 to 58% of the surgical patients deemed appropriate to having the antibiotic prophylaxis [19]. During the same time intervals the postoperative wound infections decreased from 1.8 to 0.9%. Both findings were statistically significant. Subsequent improvements in the 'process' of providing the 'prophylaxis reminders' by putting them on the surgical schedule increased the compliance to 99.1% by 1994 [28].

During the early part of the 1990s the actual 'cost' of surgical wound infections was derived from the HELP system archival files [20]. The attributable 'cost' of each surgical wound infection was US$4935 with an increased length of stay of 5.34 days, and the probability of death increased from 1.12 to 6.80%

A recent study conducted by Pestotnik and associates showed very profound effects of using the computer reminder for giving preoperative antibiotics as well as minimizing the duration of postoperative antibiotics [28]. These included:

1. a decrease in the inflation adjusted cost of antibiotics from 24.8% of the pharmacy drug expenditure (US$987 547) in 1988 to 12.9% (US$612 500) in 1994;
2. antibiotic costs per patient decreased from US$122.66 in 1988 to only US$51.90 in 1994;
3. the average number of antibiotic doses administered for surgical propilylaxis was reduced from 19.0 in 1988 to only 5.6 in 1994; and
4. adverse drug events due to antibiotic use decreased by 30%.

The recent development and evaluation of the HELP system based 'antibiotic assistant' by Evans and colleagues has shown dramatic improvements in patient care [14]. The use of the computerized 'antibiotic assistant' lead to:

1. a significant reduction in the number of antibiotics for which the patients had reported allergies;
2. reduction in the number of excess drug doses (because of the renal and body size adjustments performed by the computer);
3. reduction in the number of antibiotic-susceptibility and antibiotic drug prescribed mismatch (the computer used the micro-laboratory susceptibility data);
4. reduction in the number of adverse drug events caused by antibiotics;
5. reduction in cost of antibiotics per patients; and
6. reduction in total hospital costs and length of stay.

### 3.3. Adverse drug event detection and consequence management

Drug-related morbidity and mortality are a major cost in the United States. The excess cost of an adverse drug event (ADE) has been determined to be US$2013 at LDS

Hospital [20]. The extra length of stay was increased by 1.74 days and the mortality increased from 1.05 to 3.50% for matched controls for patients who did and did not have ADEs.

By using the HELP system to 'detect' potential adverse drug events, the number of ADEs increased from nine events reported by the 'traditional manual methods' to over 731 verified ADEs during the same time period. By using the HELP computer system as a ADE 'detector' the number of true ADEs are detected promptly, so that problems can be quickly acted upon and the detrimental effects minimized. Also, preventive measures for the most common ADEs are clearly defined, and processes can be improved to prevent many ADEs. Prevention and early treatment of ADEs can reduce length of hospitalization and result in considerable cost savings [29–33].

Other HELP decision-support tools have been evaluated. A summary of these is reported by Haug and associates [34].

## 4. Clinicians use of the HELP system

The HELP system is used by a wide variety of clinicians—physicians, nurses, nurse aids, pharmacists, physician assistants, respiratory therapists, physical therapists, etc. In addition, the system is used by unit secretaries (clerks), medical records clerks, administrators, and others.

Each patient-room is equipped with a bedside computer terminal to make data entry and review convenient and practical for the clinical staff. Nurses provide a major data input to the system with entry of observations medications given, procedures performed, some physician orders, and vital sign entry (except in the ICUs where the vital signs are automatically acquired). Presently, physicians are primarily 'data reviewers' and not 'data enterers' when using the HELP system.

To give a better understanding of the use of the HELP system, a recent survey of 'logons' into the system were evaluated and are shown in Fig. 2. For a typical 24 h period more than 12000 logons were recorded, about one logon every 7 s. Fig. 2(A) (WHO?) illustrates that nurses account for a majority of the logons, at over 47.4%. Nurse aids account for 22.9% of logons, and physicians account for 11.1% of the logons. Fig. 2(B) (WHERE?) shows that logons from acute care bedside terminals account for 51.7% of the logons in addition to another 12.1% of the logons from ICU. Bedside terminals make up 62.8% of the logons, indicating the widespread use of the bedside terminals. Fig. 2(C) (WHEN?) shows that the peak period of system use was during period 08:00–09:00 h, with over 6. 1% of the accesses occurring during this time. Note that the system use was quite uniform over the time interval from 07:00 to 18:00 h, and that even during the middle of the night the use percentage was about 2%, or about 120 logons per h. Fig. 2(D) (HOW LONG?) shows a final measure of the system, and shows that about 28% of the logons were for 1 min or less, while nearly 60% of the logons were for 3 min or less. For security/privacy, and confidentiality reasons the system logs each terminal off after a 3 min inactivity interval for bedside terminals, and a 10 min inactivity interval for nursing station terminals. In addition, any terminal user can press the F10 key to logoff at any time on their own. Terminals with longer logouts were primarily from the admitting, accounting and medical records areas where longer time-out intervals are allowed.

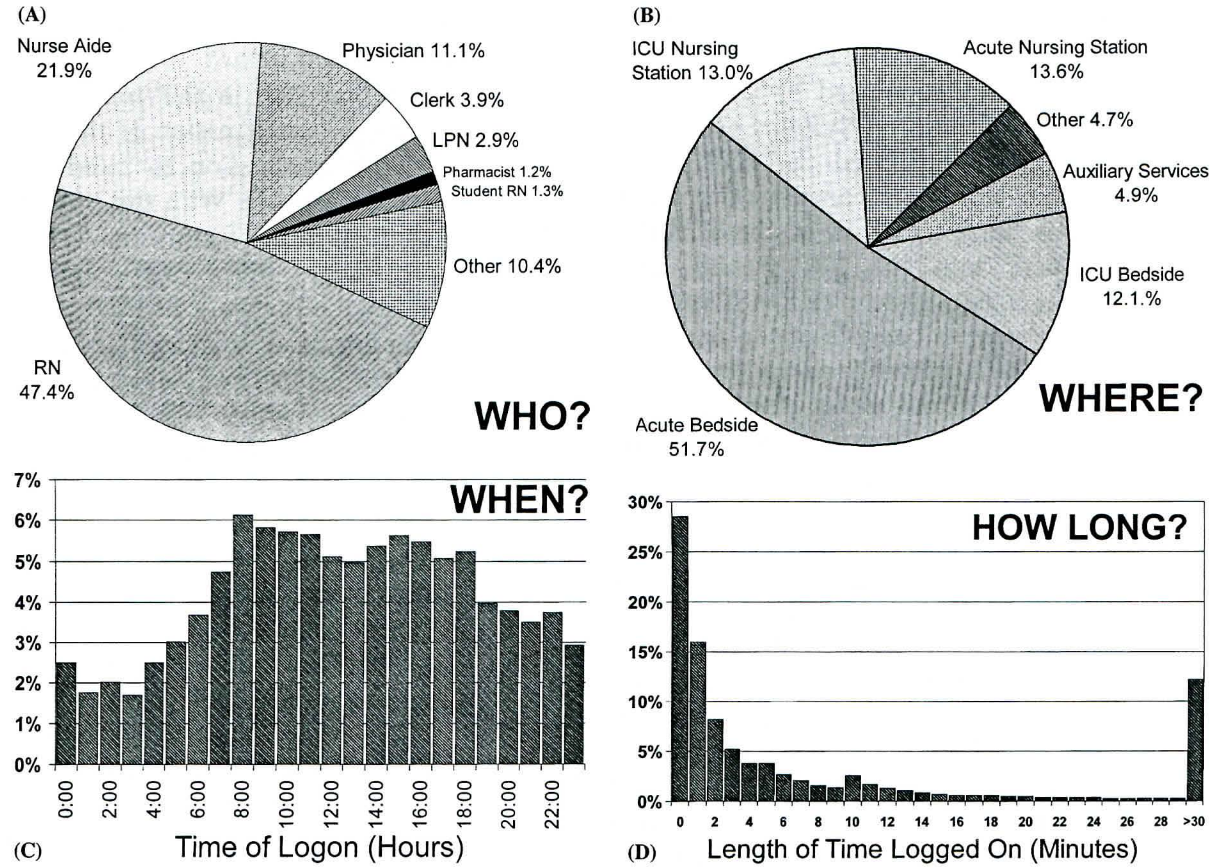


Fig. 2. Charts outlining how the HELP system is used and by whom. (A)WHO?: Indicates who the HELP systems users are. Almost half the HELP system logons are by nurses. (B) WHERE?: Shows where the HELP terminals are used. A major use of the system is from the bedside areas where the terminals are used for nursing data entry and review. (C) WHEN: Indicates when (time of day) that the HELP system is used. (D) HOW LONG?: Indicates how long the user is active at a HELP system terminal. Note that the majority of the time interactions are for less than 3 min.

## 5. Transition of HELP to next generation technology

The challenge facing us now is the need to transition the HELP system from its current legacy architecture to a more current architectural paradigm. Such a transition has become necessary both to meet the expectations of the current users and to integrate HELP into our evolving IHC-enterprise-wide information strategy. The current IHC enterprise clinical information strategy is to create an enterprise longitudinal patient data repository (LDR) and outcomes data warehouse accessible from any IHC facility. Achieving the transition of HELP into a system which incorporates both the LDR and the latest computer/user technology (graphical user interfaces (GUI) and similar capabilities) will require several changes. The transition of HELP will be implemented in a series of small operational chances, which will progressively introduce the newer computer technology into its applications while preserving the rich functionality currently supported by the HELP system. The HELP transition is being jointly supported by IHC and the 3M Health Information Systems group.

We have separated the HELP transition strategy into two concurrent projects. The first is the integration of the HELP patient database into the 3M Health Enterprise Management System (HEMS) product. The second project consists of the replacement of the HELP applications with the newer enterprise applications under development.

The HEMS product is a client/server product that consists of three major data repositories and a series of client servers. The first of the data repositories is an enterprise master member index (EMMI). The second repository is the Health Data Dictionary (HDD), which contains the definitions and mappings of all of the medical concepts supported in the patient data repository. The third repository of HEMS is the Longitudinal patient Data Repository (LDR). The LDR is the repository of patient data independent of the facility where services were rendered. The LDR has been structured so as to achieve the same functionality as the HELP patient database, but provide for longitudinal encounter based views of the patient data. Interaction with these data sources is provided through a series of UNIX based servers. All of the repositories are realized using the ORACLE database management system. Among the servers available are those to store and retrieve patient data, provide security, implement decision support, and perform data mapping between data coded from external data vocabularies and the HEMS HDD. Concurrent with the development of the HEMS UNIX servers we have been developing with 3M a client based clinical workstation (CW), initially being installed in outpatient clinics. The CW is the primary interface to the HEMS/HELP applications.

Our transition plan consists of a series of steps outlined below:

1. The first step in this transition plan has been the modification of the HELP registration application to interface with the HEMS EMMI. With this modification we eliminated the facility based HELP Master Patient Index (MPI) and rely exclusively on the EMMI for patient identification. To facilitate the use of the central EMMI, we linked all of our hospital sites together with an enterprise wide area network with sufficient bandwidth to handle the transactions occurring at all of the HELP sites.
2. The second step we have taken in transition to the enterprise system has been the transmission of the HELP database to the LDR. Our initial strategy has been to selectively begin to store subsets of the HELP database in both HELP and the enterprise LDR. This has allowed us to begin the population of the LDR while not jeopardizing the data availability and performance required to support the existing HELP applications. The initial sets of data that are being transferred to the HEMS LDR are the clinical laboratory data and the textual reports entered into HELP. Among the textual data being transferred are radiology reports, consultations, pathology reports, surgical reports, and discharge summaries. The laboratory data is transferred in parallel to both HELP and the LDR directly from the Sunquest laboratory information system. The text reports are first sent and stored in HELP and then transmitted to the LDR. Once transferred to the LDR all providers who have access to the CW (at the moment located primarily in outpatient clinics) are able to view the data from any facility within IHC.

3. The third step in our transition plan will be to modify the HEMS CW objects to interface directly to HELP as well as to the LDR. Our goal here is to sequentially replace the HELP applications with the newer GUI supported technology of the CW. We have modified the CW to write Remote Procedure Calls (RPC) to the TANDEM-based HELP servers as well as to the HEMS servers. Using RPC technology we will first concentrate on user functionality while maintaining the back-end HELP servers. Our first use of the RPC with the HELP system has been with the development of a CW/HELP laboratory order entry front end that communicates directly with the HELP order server. Eventually we will replace the HELP patient documentation applications, such as nursing and pharmacy, with GUI applications being developed using the CW.
4. The final step will be to use the technology of the CW and its ability to communicate either with HELP or HEMS. When the functionality of the HEMS servers reach the same level as HELP, outputs from the HEMS servers will be sent directly to CW rather than running on the HELP system. At that point HELP will be modified to talk directly to HEMS for those data that are required for applications still running on HELP. We believe the above outlined strategy will enable us to transition applications to HEMS as time and resources permit, with minimal impact on our clinical users.

## 6. Barriers to wider use of the HELP system

As can be noted from Table 1, the distribution of the HELP system to other IHC facilities has taken several years. It can also be noted from the table that not all of the clinical applications running at LDS Hospital are being used at the other eight IHC hospitals. The major barriers to more widespread use of the HELP system within IHC and for hospitals outside IHC are the following:

1. Having a clinical and administrative staff who are ready for the 'culture' and 'process' changes needed to install operate and optimize patient care using computers. Even though most of the hospitals within IHC have worked together for several decades and have had some central management, there are still very large individual differences and the feeling that each hospital is 'unique' and must do things differently. Such an attitude and practice makes it very difficult to implement and maintain consistent computer systems.
2. It takes someone with vision and perseverance to go through the initial 'startup' process to get such clinical computing systems operational. For example, at the first IHC installation outside LDS Hospital a manager who had primarily an accounting system background was assigned to implement the system. Within 1 year the HELP system at that site began to look like a billing/accounting system rather than a clinical computing system. The manager did an excellent management job but did not have the vision of what a clinical and clinical decision support system was. Hence, in recent years clinical medical informatics specialists, primarily physicians, have been assigned to the major HELP system sites.
3. The initial investment is large. The initial hardware costs as well as the costs of training personnel are large. It is surprising that in 1998 many clinical staff (nurses and physicians) are not familiar with use of computers and the 'Windows 95' operating system. As a result, these staff mem-

bers are nervous about 'charting' into a system and being able to retrieve their data. Use of pencil/pen and paper have been programmed into everyone since childhood so effectively that converting to computer methods is a real 'shock' for many of our clinical staff.
4. The return on investment does not accrue quickly. Because the clinical implementation steps each take some time to be completed and since the more sophisticated applications depend on a robust and nominally complete integrated database, those applications cannot be implemented immediately.
5. It has only been in recent years that the value of having an 'integrated' and 'lifelong' medical record covering inpatient as well as outpatient care has been recognized. The HELP system was designed to be primarily an 'inpatient' system. Moving toward an integrated record system with care being provided for the same patient by multiple different individual providers was not anticipated in the initial HELP system design.

## 7. Conclusion

The HELP system is one of the longest running and most successful clinical information systems. Concepts developed with the HELP system have shown:
1. that clinical care can be provided with such a system;
2. that computerized decision-support is feasible;
3. that computerized decision-support can aid in providing more cost-effective and improved patient care; and
4. that clinical user attitudes toward computerized decision-support are positive and supportive.

The major challenges with the 'success' of the HELP system is to be able to move forward into the next generation of enterprise-wide 'integrated' clinical information systems. The experience provided during the development of the HELP system gives us confidence and enthusiasm to develop the next generation of computerized patient record and decision-support systems.

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